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# MATERIALS SCIENCE AND ENGINEERING

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## *Ramesh K Agarwal*

*Washington University in St. Louis, USA*

### **Design of metamaterials using transformation physics**

Metamaterials are rationally designed artificial materials composed of tailored functional building blocks densely packed into an effective (crystalline) material. While metamaterials historically are primarily thought to be associated with negative refractive indices and invisibility cloaking in electromagnetism or optics, it turns out that the simple metamaterial concept also applies to many other areas of physics namely the thermodynamics, classical mechanics (including elastostatics, acoustics, fluid dynamics and elastodynamics) and in principle also to the quantum mechanics. This lecture will review the basic concepts and analogies behind the thermodynamic, acoustic, elastodynamic/elastostatic, and electromagnetic metamaterials and differences among them. It will provide an overview of the theory, the current state of the art and example applications of various types of metamaterials. The review will also discuss the homogeneous as well as inhomogeneous metamaterial architectures designed by coordinate-transformation-based approaches analogous to transformation optics. The application examples will include laminates, thermal cloaks, thermal concentrators and inverters, anisotropic acoustic metamaterials, acoustic free-space and carpet cloaks, and mechanical metamaterials with negative dynamic mass density, negative dynamic bulk modulus, or negative phase velocity. Finally an example of quantum-mechanical matter-wave cloaking will be provided.

### **Biography**

Professor Ramesh K. Agarwal is the William Palm Professor of Engineering at Washington University in St. Louis. From 1994 to 2001, he was the Sam Bloomfield Distinguished Professor and Executive Director of the National Institute for Aviation Research at Wichita State University in Kansas. From 1978 to 1994, he worked in various scientific and managerial positions at McDonnell Douglas Research Laboratories in St. Louis. He became the Program Director and McDonnell Douglas Fellow in 1990. Dr. Agarwal received Ph.D in Aeronautical Sciences from Stanford University in 1975, M.S. in Aeronautical Engineering from the University of Minnesota in 1969 and B.S. in Mechanical Engineering from Indian Institute of Technology, Kharagpur, India in 1968. He is the author and coauthor of over 600 publications and serves on the editorial board of 20+ journals. He has given many plenary, keynote and invited lectures at various national and international conferences worldwide. He is a Fellow of AAAS, ASME, AIAA, IEEE, SAE and SME.

rka@wustl.edu

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